

## CHAPTER 10. OTHER DELINEATION DEVICES

### INTRODUCTION

Other types of delineation devices are used to supplement standard pavement markings. This chapter addresses object markers, warning signs, barrier delineators, and pavement symbols.

### USES

Object markers, warning signs, and barrier delineators give warnings and are used where pavement markings alone do not provide enough information on road alignment or roadside features for a driver to negotiate a road section or avoid obstructions. Pavement symbols are used to reinforce regulations, warn drivers, and provide guidance information.

### Object Markers

Object markers identify obstructions within or adjacent to the roadway. The three types of object markers are illustrated in figure 62. When used, these markers should be arranged in one or more of these three designs.

*Type 1.* Either a marker consisting of nine yellow retroreflectors, each with a minimum dimension of about 3 inches (76 millimeters), mounted symmetrically on an H-inch (457-millimeter) yellow or black diamond-shaped panel; or an all-yellow retroreflective diamond-shaped panel of the same size. Type 1 markers may be larger if conditions warrant.

*Type 2.* Either a marker consisting of three yellow retroreflectors, each with a minimum dimension of about 3 inches (76 millimeters), arranged either horizontally or

vertically; or an all-yellow retroreflective panel, 6 by 12 inches (150 by 300 millimeters). Type 2 markers may be larger if conditions warrant.

*Type 3.* A marker consisting of a vertical rectangle about 1 by 3 feet (0.3 by 0.9 meter) in size with alternating black and retroreflective yellow stripes sloping downward at an angle of 45 degrees (0.785 radian) toward the side of the obstruction on which traffic is to pass. The minimum width of the yellow stripe should be 3 inches (76 millimeters). A better appearance can be achieved if the black stripes are wider than the yellow stripes.

Left object markers (OM-3L) have stripes that begin at the upper left side and slope downward to the lower right side. Right object (OM-3R) marker stripes begin at the upper right side and slope downward to the lower left.

### *Objects in the Roadway*

Obstructions in the roadway should be marked with a Type 1 or Type 3 object marker. A large surface, such as a bridge pier, may be painted with diagonal stripes, 12 inches (300 centimeters) or greater in width, similar in design to the Type 3 object marker. Alternating black and yellow retroreflective stripes should slope downward at a 45 degree angle toward the side of the obstruction that traffic is to pass.

Appropriate signs (*MUTCD* sections 2B-25 and 2C-33) directing traffic to one or both sides of the obstruction may be used in lieu of the object marker. In addition to markings on the face of an obstruction in the roadway, warning of approach to the

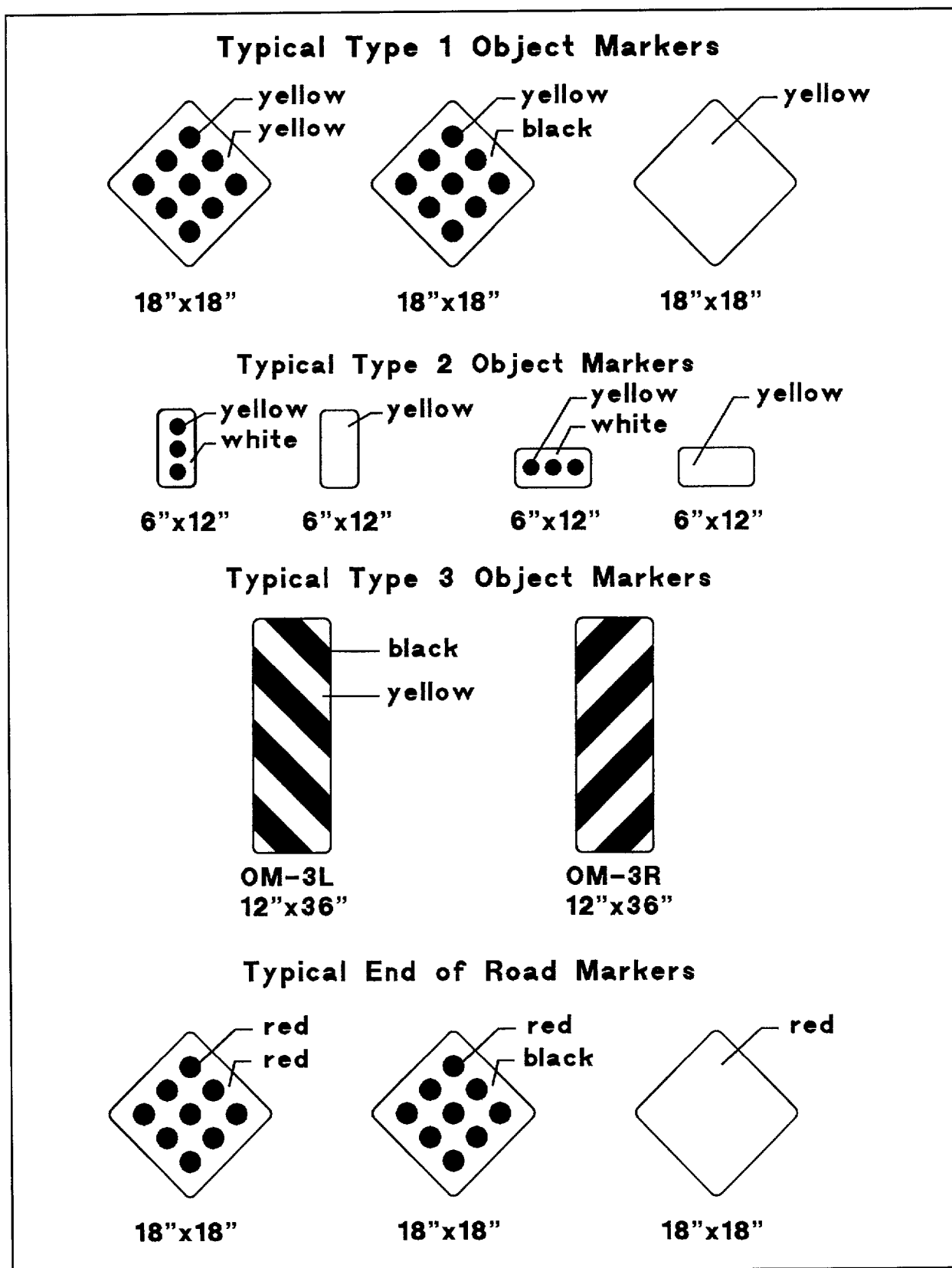


Figure 62. Object markers

obstruction should be given by appropriate pavement markings (*MUTCD* section 3B-13).

Where the vertical clearance of an overhead structure exceeds the maximum legal height of a vehicle by less than 1 foot (0.3 meters), the clearance in feet and inches should be clearly marked on the structure (*MUTCD* section 2C-34).

#### *Objects Adjacent to Roadway*

Objects not actually in the roadway may be so close to the edge of the road that they need a marker. Such objects include underpass piers, bridge abutments, handrails, and culvert headwalls. In some cases, there may not be a physical object involved, but other roadside conditions, such as narrow shoulder drop-offs, gores, small islands, and abrupt changes in the roadway alignment, may make it undesirable for a driver to leave the roadway. Type 2 or Type 3 object markers are intended for use at these locations. The inside edge of the marker should be in line with the inner edge of the obstruction.

Standard warning signs (*MUTCD* section 2C) should also be used where applicable.

#### *End of Roadway*

When it is determined that object markers should be placed at the end of a roadway where there is no alternate vehicular path, either a marker consisting of nine red retroreflectors, each with a minimum dimension of approximately 3 inches (76 millimeters), mounted symmetrically on an 18-inch (457 millimeter) diamond-shaped, red or black panel; or an 18-inch (45.7-centimeter) diamond-shaped retroreflective red panel should be used. More than one marker or a larger marker may be used at the end of the roadway where conditions warrant. Appropriate advance warning signs should be used.

### **Warning Signs**

Warning signs supplement pavement markings and consist of the alignment series and the Advisory Speed plate, Large Arrow and Chevron Alignment signs. Figure 63 shows the alignment series warning signs.

#### *Turn Sign (W1-1)*

The Turn sign (W1-1R or W1-1L) is used where engineering investigations of roadway, geometric, and operating conditions show the recommended speed on a turn to be 30 miles per hour (48 kilometers per hour) or less, and this recommended speed is equal to or less than the speed limit established by law or regulation for that section of roadway. Where a Turn sign is warranted, a Large Arrow sign (*MUTCD* section 2C-9) may be used on the outside of the turn. Additional protection may be provided by use of the Advisory Speed plate (*MUTCD* section 2C-35).

#### *Curve Sign (W1-2)*

The Curve sign (W1-2R or W1-2L) may be used where engineering investigations of roadway, geometric, and operating conditions show the recommended speed on the curve to be greater than 30 miles per hour (48 kilometers per hour) and equal to or less than the speed limit established by law or by regulation for that section of roadway. Additional protection may be provided by use of the Advisory Speed plate (*MUTCD* section 2C-35).

#### *Reverse Turn Sign (W1-3)*

The Reverse Turn sign is used to mark two turns or a curve and a turn in opposing directions, as defined in the warrants for Turn and Curve signs (*MUTCD* sections 2C-4 and 2C-5) that are separated by a tangent of less than 600 feet (183 meters). If the first turn is to the right, a Right Reverse Turn sign (W1-3R) should be used; if the

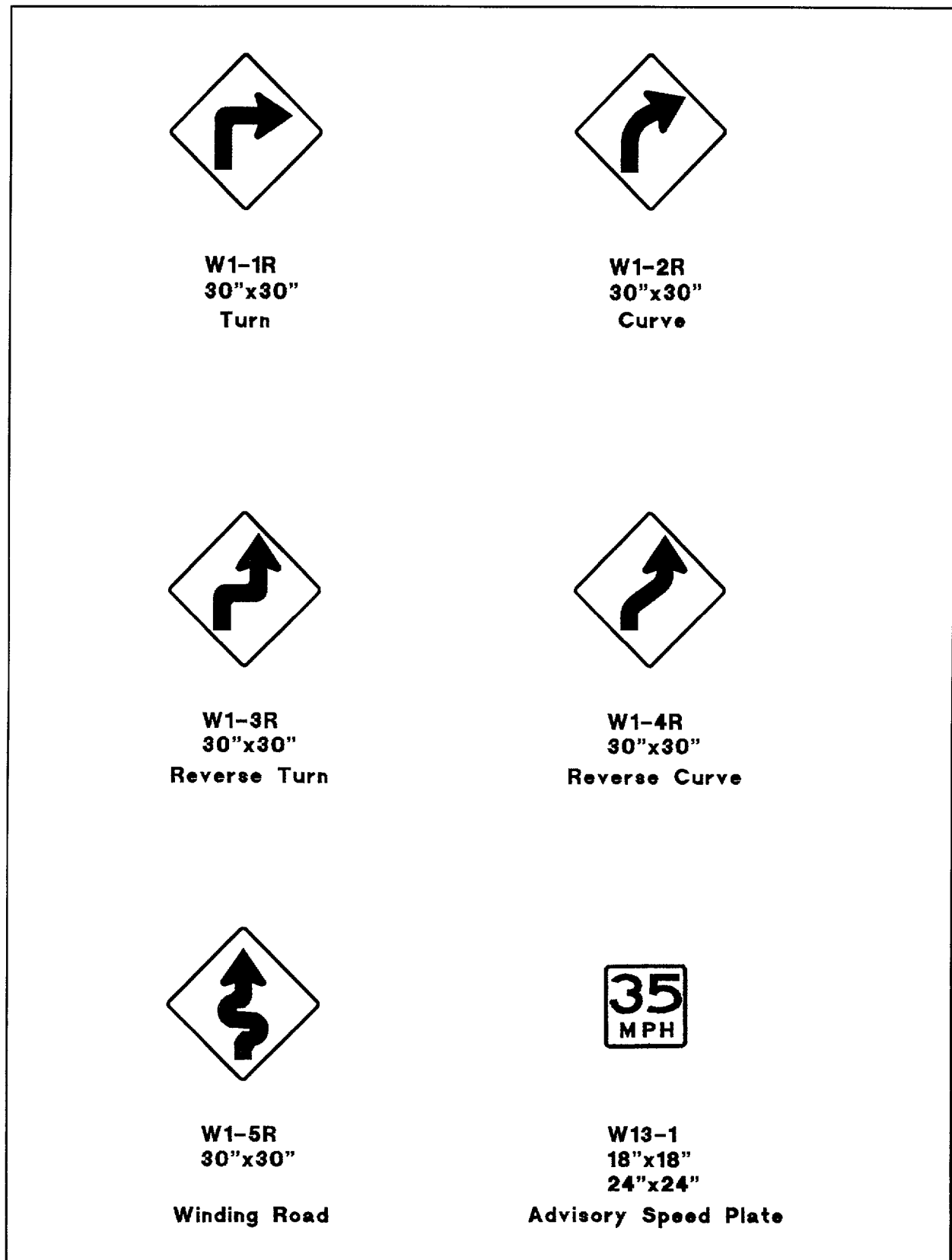


Figure 63. Alignment series and advisory speed plate

first turn is to the left, a Left Reverse Turn sign (W1-3L) should be used. For additional protection the Advisory Speed plate (MUTCD section 2C-35) may be used.

#### *Reverse Curve Sign (W1-4)*

The Reverse Curve sign is used to mark two curves in opposite directions, as defined in the warrants for Curve signs (MUTCD section 2C-5) that are separated by a tangent of less than 600 feet (183 meters). If the first curve is to the right, a Right Reverse Curve sign (W1-4R) should be used; if the first curve is to the left, a Left Reverse Curve sign (W1-4L) should be used.

#### *Winding Road Sign (W1-5)*

The Winding Road sign is used where there are three or more turns or curves, as defined in the warrants for Turn and Curve signs (MUTCD Sections 2C-4 and 5), separated by tangent distances of less than 600 feet (183 meters). The Winding Road sign should be erected in advance of the first curve. Where the three or more turns or curves extend over a roadway section of 1 mile (1.6 kilometers) or more, the supplemental plaque Next X Miles (W7-3a) may be installed below the Winding Road sign. Additional warning may be provided by the installation of raised pavement markers (MUTCD section 3D-4) and by use of the Advisory Speed plate (MUTCD section 2C-35).

#### *Advisory Speed Plate (W13-1)*

The Advisory Speed plate, shown in figure 63, is used to supplement warning signs. The standard size of the Advisory Speed plate is 18 by 18 inches (457 by 457 millimeters). Advisory Speed plates used with 36-inch (914-millimeters) and larger warning signs should be 24 by 24 inches (610 by 610 millimeters).

The Advisory Speed plate should carry the speed message in black letters on a yellow background (MUTCD section 6B-34).

When used for construction or maintenance work zones, the message should be in black on an orange background. The speed shown should be a multiple of 5 miles per hour (8 kilometers per hour). The plate may be used in conjunction with any standard yellow warning sign to indicate the maximum recommended speed on a curve or through a hazardous location. It should not be used in conjunction with any sign other than a warning sign, nor should it be used alone. It should be mounted on the same assembly and normally below the standard warning sign. Except in emergencies or at construction or maintenance sites, where the situation calling for an Advisory Speed plate is temporary, an Advisory Speed plate should not be erected until the recommended speed has been determined by accepted traffic engineering procedures. Because changes in surface characteristics, sight distance, and other factors may alter the recommended speed, each location should be periodically checked and the plate corrected if necessary.

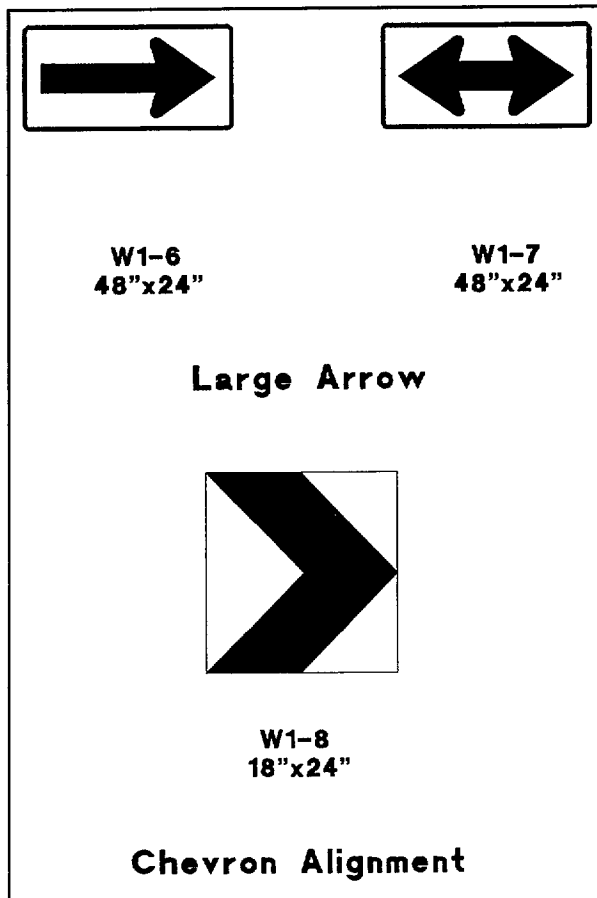
#### *Large Arrow Sign (W1 -6, W1 -7)*

The Large Arrow sign is used to give notice of a sharp change of alignment in the direction of travel. It is not to be used where there is no change in the direction of travel (ends of medians, center piers, etc.). The Large Arrow sign should be a horizontal rectangle with a standard size of 48 by 24 inches (1,220 by 610 millimeters), having a large arrow (W1-6) or a double head arrow (W1-7). It should have a yellow background with the symbol in black. Figure 64 shows the Large Arrow signs. The Large Arrow sign should be erected on the outside of a curve or on the far side of an intersection in line with, and at right angles to, approaching traffic.

The Large Arrow sign should be visible for at least 500 feet (153 meters). Trial runs by day and night may be desirable to determine final positioning.

*Chevron Alignment Sign (W1-8)*

A Chevron Alignment sign (figure 64) may be used as an alternative or supplement to standard delineators and to the Large Arrow sign. The Chevron Alignment sign gives notice of a sharp change in roadway alignment. The Chevron Alignment sign provides additional emphasis and guidance for drivers as to changes in horizontal alignment of the roadway.



**Figure 64** Large arrow and chevron alignment signs

The Chevron Alignment sign should be a vertical rectangle with a minimum size of 12 by 18 inches (305 by 457 millimeters). It should have a yellow background with chevron symbol in black. The size of sign used will be determined by an engineering investigation.

The Chevron Alignment sign is erected on the outside of a curve, sharp turn, or on the far side of an intersection, in line with and at right angles to approaching traffic. Signs should be spaced so that two of the signs will always be visible to the driver, until the change in alignment eliminates the need for the signs. Chevron Alignment signs should be visible for at least 500 feet (153 meters); trial runs by day and night may be desirable to determine final positioning.

**Barrier Delineators**

Barrier delineators are retroreflective units that mount on guardrails, concrete barriers, and bridge parapets. They are white or amber to conform with the pavement marking they supplement. Figure 65 shows examples of barrier delineators. The reflective units are made of high-intensity retroreflective sheeting or cube corner retroreflectors. Barrier delineators should not be substituted for post-mounted delineators.

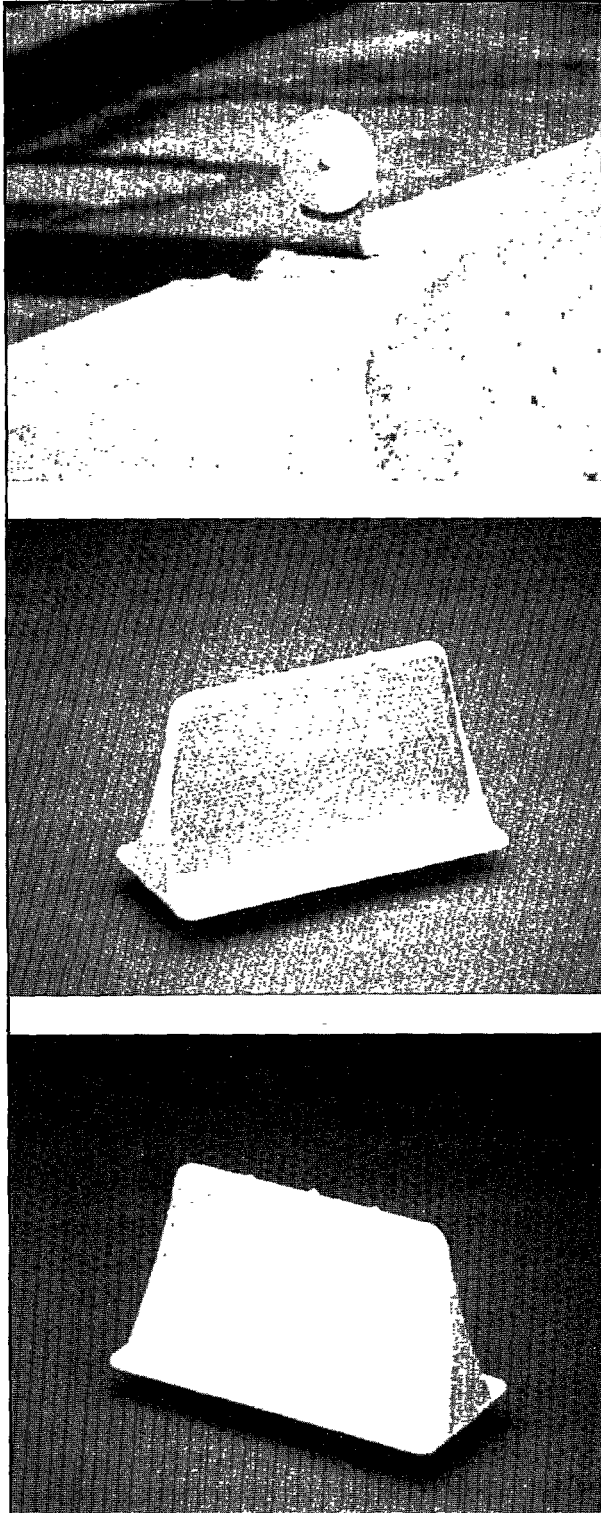
**Pavement Symbols**

Word and symbol markings on the pavement guide, warn, or regulate traffic. They should be limited to not more than three lines of information. They shall be white and, if used at nighttime, should be retroreflective. They consist of crosswalk markings, parking space markings, turning and lane use arrows, pavement and word symbols, curb markings for parking restrictions, wrong way arrows, preferential lane use markings, speed measurement markings, railroad crossing markings, bicycle markings, and other markings.

*Crosswalk Markings*

Crosswalk markings at signalized intersections, and across intersectional approaches on which traffic stops, serve primarily to guide pedestrians in the proper paths. Crosswalk markings across roadways on which traffic is not controlled by traffic signals or Stop signs also warn drivers of a

pedestrian crossing point. At nonintersectional locations, these markings legally establish the crosswalk.



**Figure 65** Barrier delineators

Crosswalk markings shall be solid white, marking both edges of the crosswalk. They should be not less than 6 inches (152 millimeters) wide and should not be spaced less than 6 feet (1.8 meters) apart. Under special circumstances where a stop bar is not provided, or where vehicular speeds exceed 35 miles per hour (56 kilometers per hour), or where crosswalks are unexpected, it may be desirable to increase the width of the crosswalk marking to 24 inches (610 millimeters). Crosswalk markings on both sides of the crosswalk should extend across the full width of pavement to discourage diagonal walking between crosswalks. Crosswalk markings are shown in figure 66.

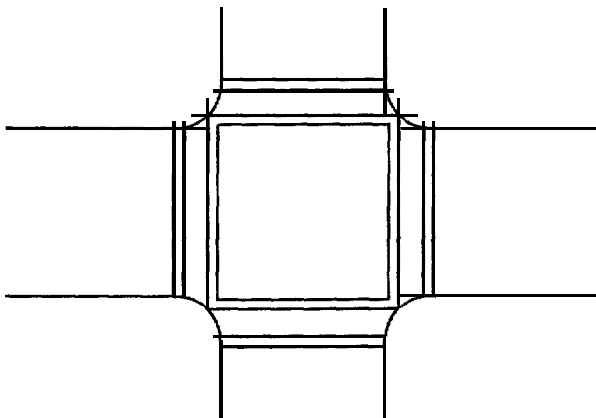
Crosswalks should be marked at all intersections where there is substantial conflict between vehicle and pedestrian movements. Marked crosswalks should also be provided at other appropriate points of pedestrian concentration, such as at loading islands, midblock pedestrian crossing, or where pedestrians could not otherwise recognize the proper place to cross.

Crosswalk markings should not be used indiscriminately. An engineering study should be performed before they are installed at locations away from traffic signals or stop signs.

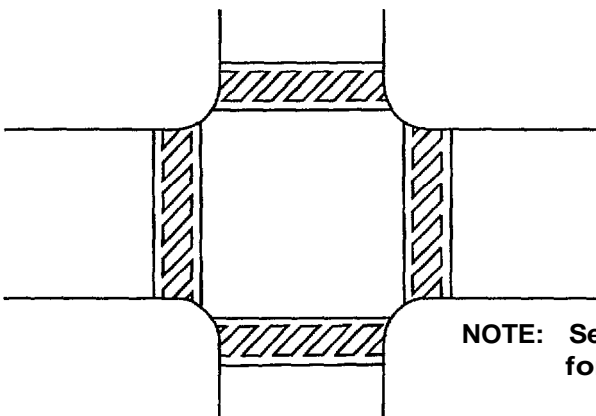
Since nonintersectional pedestrian crossings generally are unexpected by the driver, warning signs (*MUTCD* section 2C-31) should be installed and adequate visibility provided by parking prohibitions.

For added visibility, the area of the crosswalk may be marked with white diagonal markings at a 45-degree angle or with white longitudinal markings at a 90-degree angle to the line of the crosswalk. These markings should be 12 to 24 inches (305 to 610 centimeters) wide and spaced 12 to 24 inches (305 to 610 centimeters) apart. When diagonal or longitudinal markings are used to mark a crosswalk, the transverse crosswalk markings may be omitted. This type of marking is used at locations where

**a - Standard crosswalk marking.**

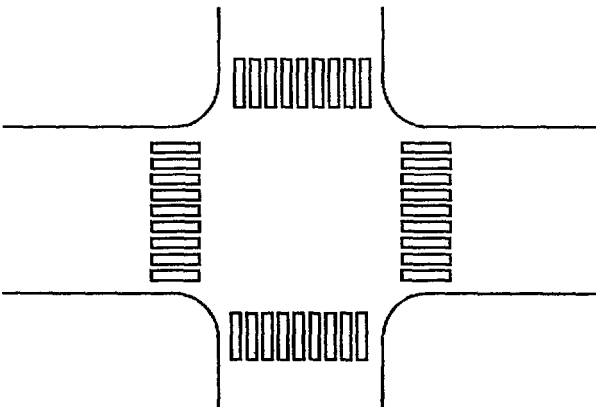


**b- Crosswalk marking with diagonal lines for added visibility.**



**NOTE:** See MUTCD Sec. 3B-15  
for line dimensions.

**c - Crosswalk marking with longitudinal lines for added visibility.**



**Figure 66.** Typical crosswalk markings

substantial numbers of pedestrians cross without any other traffic control device, at locations where physical conditions are such that added visibility of the crosswalk is desired, or in locations where a pedestrian crosswalk might not be expected. Take care to ensure that crosswalks with diagonal or longitudinal markings used at some locations do not weaken or detract from other crosswalks (where special emphasis markings are not used).

When an exclusive pedestrian phase signal, which permits diagonal crossing, is installed at an intersection, a unique marking may be used for the crosswalk (figure 67).

### *Parking Space Markings*

Parking space markings on urban streets encourage orderly and efficient use of parking spaces. They tend to prevent encroachment on fire hydrant zones, bus stops, loading zones, approaches to corners, clearance spaces for islands and other zones where parking is prohibited. Parking space markings should be white. Typical parking space markings are shown in figure 68.

### *Turning and Lane Use Arrows*

Lane use arrows may be used to convey either guidance or mandatory messages. However, where symbol arrows are used to convey a mandatory movement, lane-use arrow markings should be used and must be accompanied by standard signs and the word marking "ONLY." Lane use arrows may also be used in two-way left turn lanes and in all right and left turn bays. Signs or markings should be repeated in advance of mandatory turn lanes when necessary to prevent entrapment and to help drivers select the appropriate lane before reaching the end of the line of waiting vehicles.

### *Pavement Letters and Numerals*

All letters, numerals and symbols should conform to the *Standard Alphabets for*

*Highway Signs and Pavement Markings.* "Use large letters and numerals, 8 feet (2.4 meters) or more in height. If the message consists of more than one word, the message should read "up"; that is, the first word should be nearest to the driver. Symbol messages are preferable to word messages. Figure 69 shows the use of word and symbol markings on the pavement.

Where speeds are low, the sizes of letters, numerals, and symbol arrows may be reduced approximately one-third. The longitudinal space between word or symbol messages, including arrows, should be at least 4 times the height of the character for low speed roads but not more than 10 times the height of the character under any conditions. Examples of standard words and arrow pavement markings are shown in figures 70 through 72. Alternate (narrower) symbol arrows may be used in lieu of standard arrows.

Word and symbol markings considered appropriate for use when warranted include the following:

#### *Regulatory*

STOP	SYMBOL ARROWS
RIGHT TURN ONLY 25 MPH, OPTIONAL	
LEFT TURN ONLY	SYMBOL ARROWS

#### *Warning*

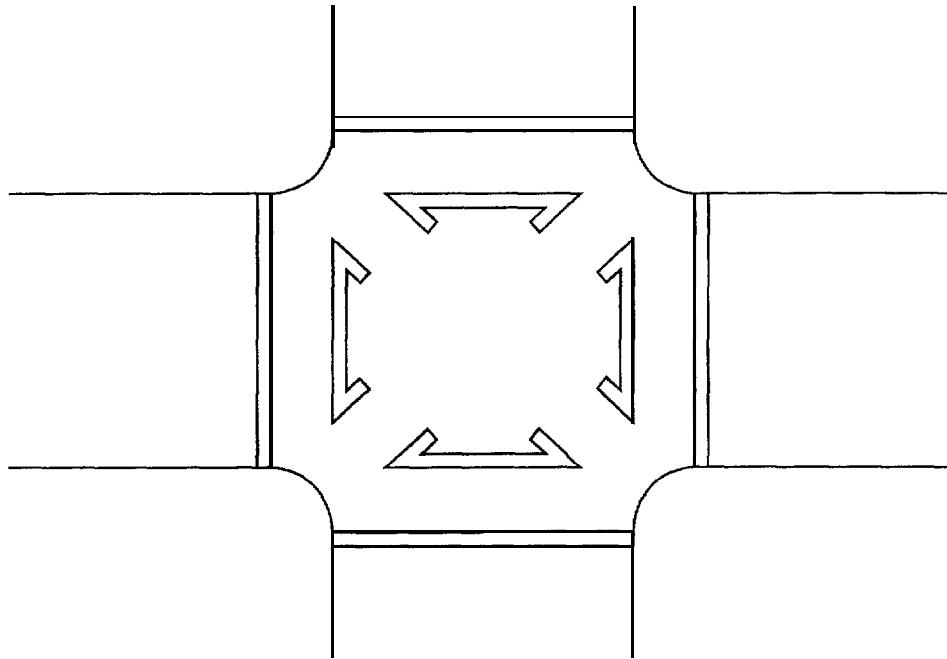
STOP AHEAD	SCHOOL XING
SIGNAL AHEAD	PED XING
SCHOOL	R X R

#### *Guide*

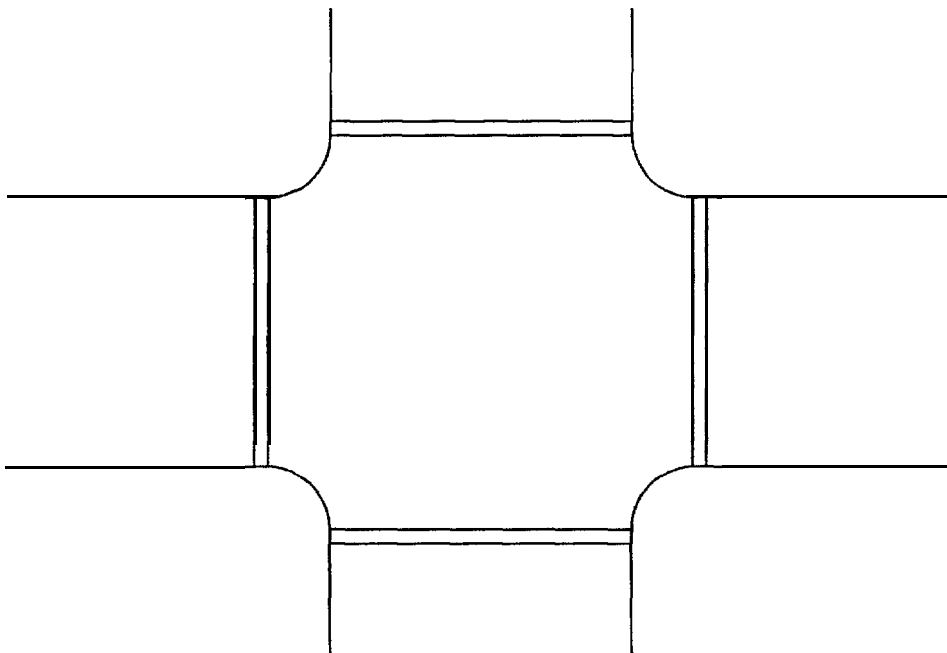
US 40	STATE 135
ROUTE 81	HWY 21

Other words or symbols may be necessary under certain conditions.

Because uncontrolled use of pavement markings can confuse drivers, the number of different word and symbol markings should be minimized.



**a - Crosswalk marking that outlines pedestrian travel paths.**



**b- Crosswalk marking that outlines the edge of pedestrian travel area.**

**Figure 67.** Typical crosswalk markings for exclusive pedestrian phase

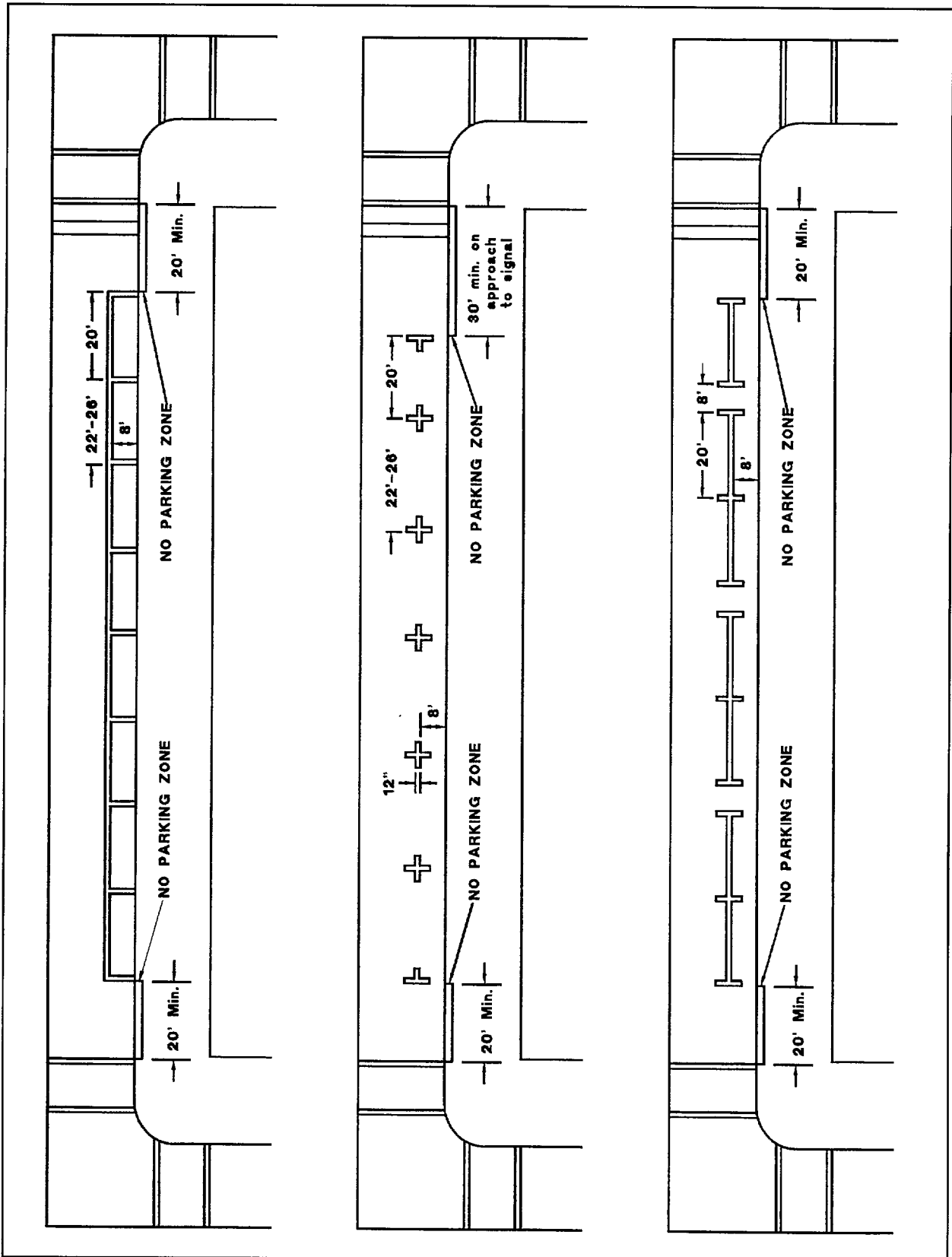


Figure 68. Typical parking space limit markings

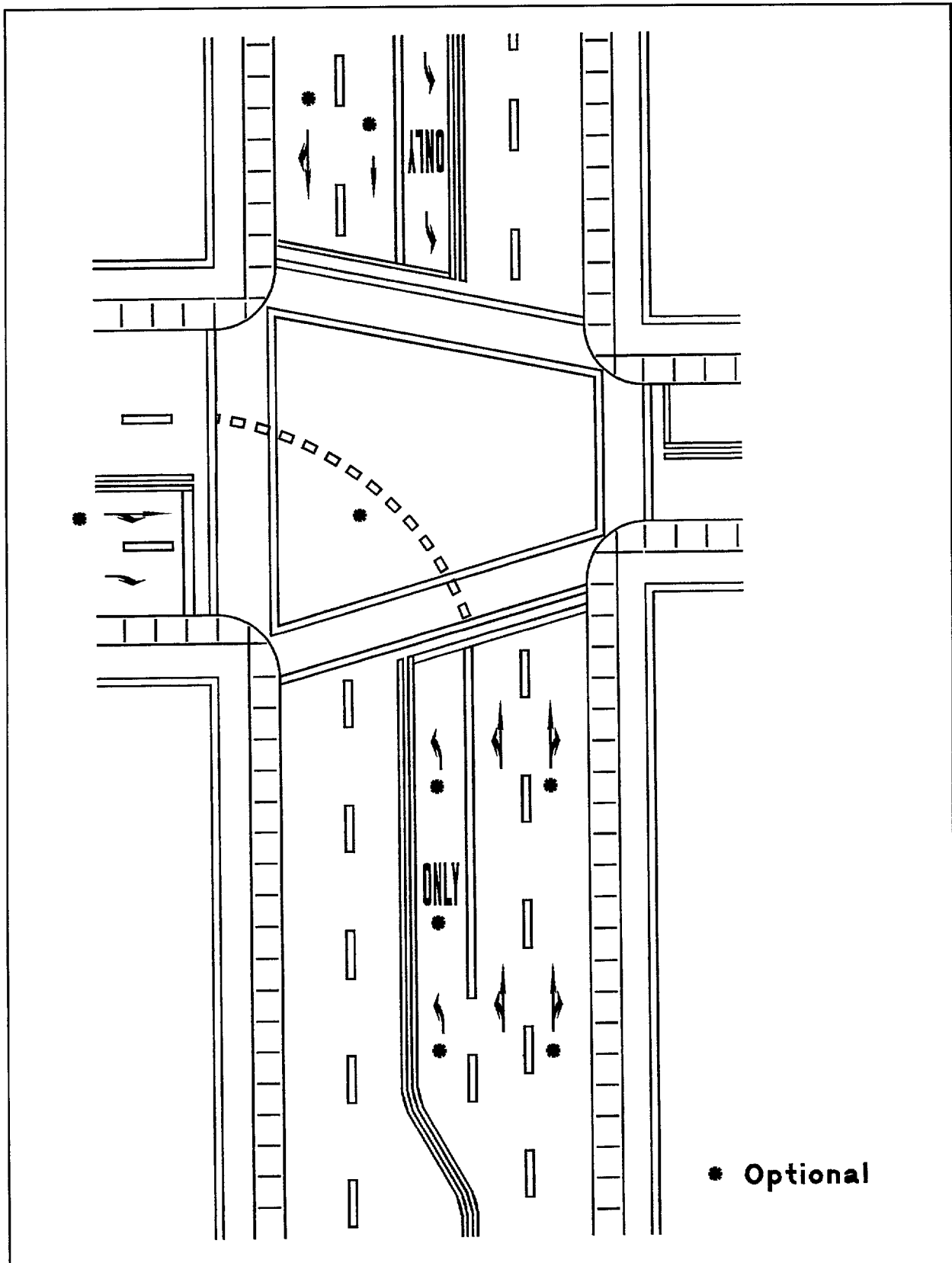


Figure 69. Typical lane-use-control word and symbol markings

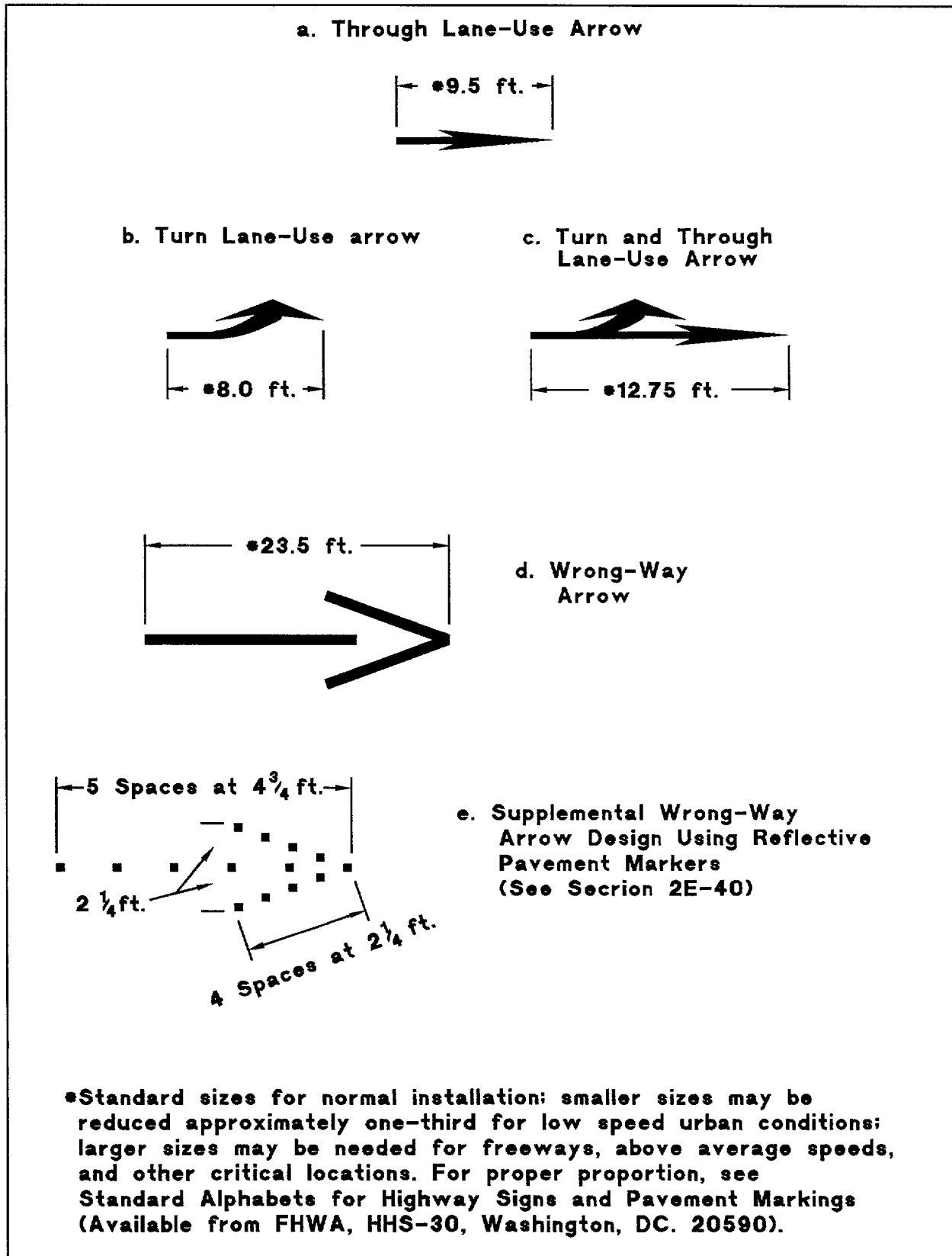
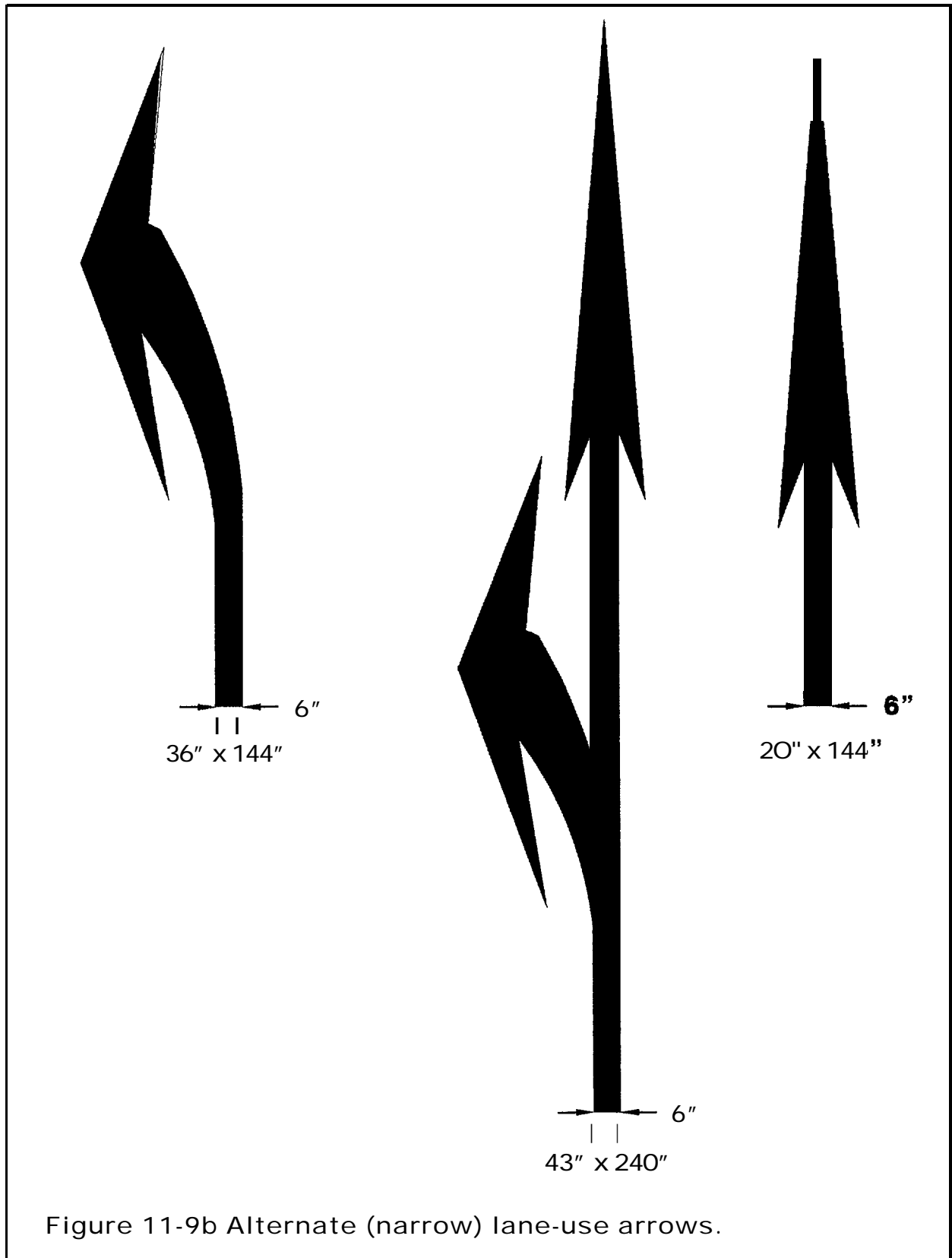


Figure 70. Lane-use and wrong-way arrows for pavement markings



**Figure 71.** Narrow turning and lane-use arrows

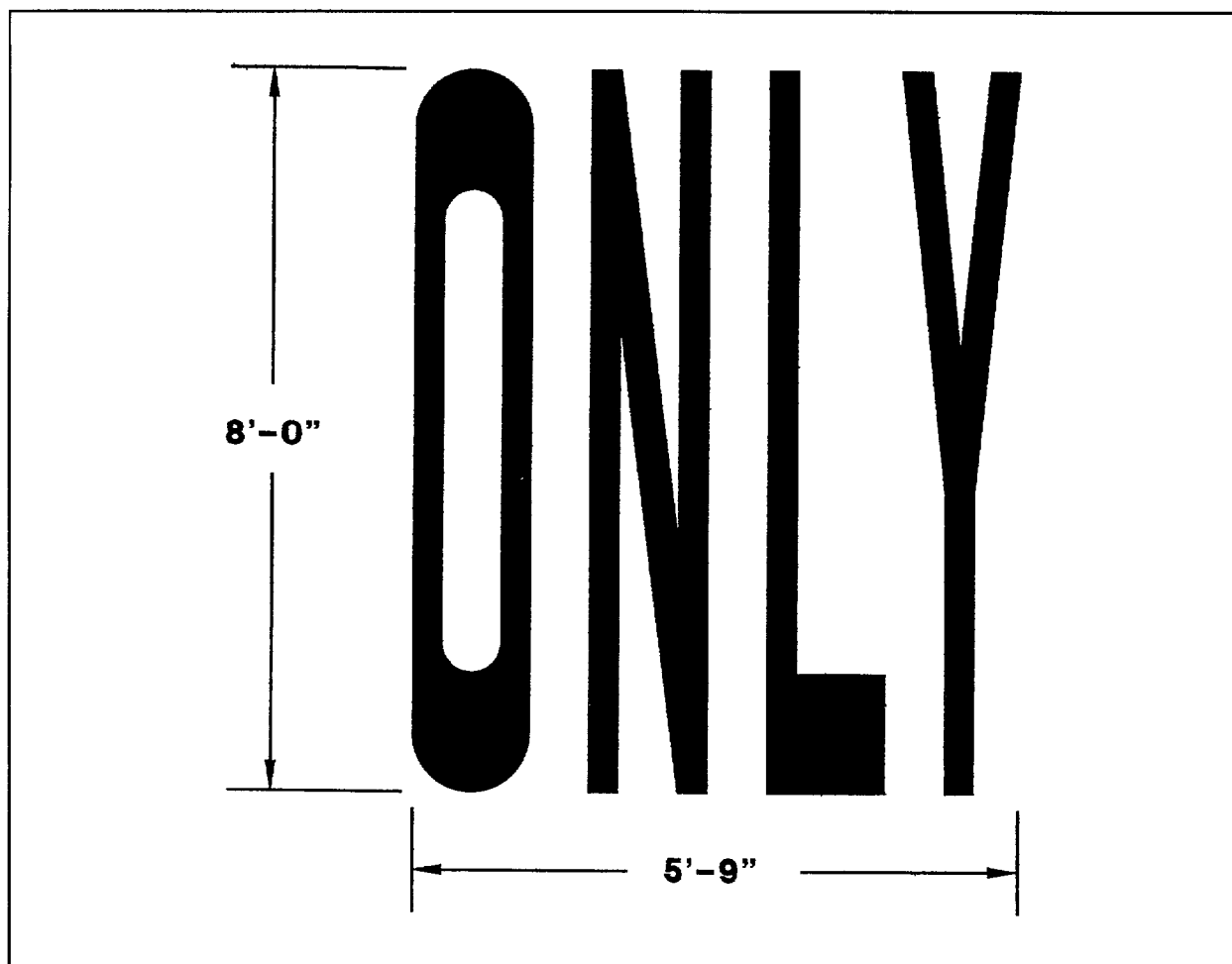


Figure 72. Elongated letters for pavement marking

The word "STOP" should not be used on the pavement unless accompanied by a stop bar (*MUTCD* section 3B-17) and Stop sign (*MUTCD* section 2B-4). The word "STOP" should not be used on the pavement in advance of a stop bar, unless every vehicle is required to stop at all times.

Except for the "SCHOOL" message, pavement messages should be no more than one lane in width (*MUTCD* section 7C-6).

#### *Curb Markings for Parking Restrictions*

Because curb markings in yellow and white are used for delineation and visibility, it is usually advisable to establish parking regulations through the installation of standard signs (*MUTCD* sections 2B-31 to 2B-33). However, when local authorities

prescribe special colors for curb markings as supplemental to standard signs, they may be used. When signs are not used, the intended meaning should be stenciled on the curb. Signs should always be used with curb markings in those areas where curb markings are frequently obliterated by accumulations of snow and ice.

#### *Preferential Lane Markings*

Preferential Lane markings convey a restriction on the class or classes of vehicles permitted to use the lane, and they supplement signs or signals conveying the specific restrictions. Signs or signals should be used with the preferential lane markings.

When a lane is assigned full time or part time to a particular class or several

classes of vehicles, the preferential lane marking should be used. Preferential lanes may operate for only certain periods of the day and may occupy portions of the roadway not normally designed for that purpose. In these cases, markings should conform to the purpose the lane serves a majority of the time. Engineering judgment should be exercised to determine the need for supplemental devices such as tubular markers, traffic cones, and flashing lights.

Preferential Lane markings should be the elongated diamond shape detailed in the *Standard Alphabets for Highway Signs and Pavement Markings*.<sup>(87)</sup> The diamond should be formed by white markings at least 6 inches (152 millimeters) wide. The diamond shape should be at least 2 1/2 feet (0.76 meters) wide and 12 feet (3.7 meters) long, and should be placed coincident with the longitudinal center of each restricted lane.

The frequency with which the marking is placed is a matter for engineering judgment based on prevailing speed, block lengths, distance from intersections, and other considerations necessary to adequately communicate with the driver. Spacing as close as 80 feet (24 meters) may be appropriate for a city street, while a spacing of 1,000 feet (305 meters) may be appropriate for a freeway.

Word markings may be used to supplement, but not substitute for, the preferential lane markings.

### *Speed Measurement Markings*

Speed Measurement markings are transverse markings placed on the pavement to enforcement of speed regulations. Speed measurement markings should be white, and should be not greater than 24 inches (610 millimeters) wide. They may extend about 2 feet (0.6 meters) on either side of the centerline or edgeline of the roadway at 1/4-mile (0.8-kilometer) intervals more than a 1-mile (1.6-kilometer) section of

roadway. Advisory speed plates may be used in conjunction with these markings.

### *Railroad Crossing Markings*

Pavement symbols in advance of a railroad crossing should consist of an "X," the letters "RR," a no passing marking (two-lane roadways), and transverse markings. Identical markings should be placed in each approach lane on all paved approaches to railroad crossings where crossing signals or automatic gates are located, and at all other railroad crossings where the prevailing traffic speed is 40 miles per hour (64 kilometers per hour) or greater. A portion of the pavement marking symbol should be directly opposite the advance warning sign. If needed, supplemental pavement markings may be placed between the advance warning sign and the crossing.

The marking should also be placed at railroad crossings where the engineering studies indicate there is a significant potential conflict between vehicles and trains. At minor crossings or in urban areas, these markings may be omitted if engineering study indicates that other devices installed provide suitable control.

The design of railroad crossing pavement markings should be as illustrated in figure 73. The symbols and letters are elongated to allow for the low angle at which they are viewed. All markings should be retroreflective white except for the no-passing markings that should be retroreflective yellow. Figure 74 shows the alternate narrow X and the letters RR.

### *Bicycle Markings*

Pavement markings are important on roadways that have a designated bicycle lane. Markings indicate the separation of the lanes for automobiles and bicycles, assist the bicyclist by indicating assigned travel paths, and can provide advance information for turning and crossing maneuvers.

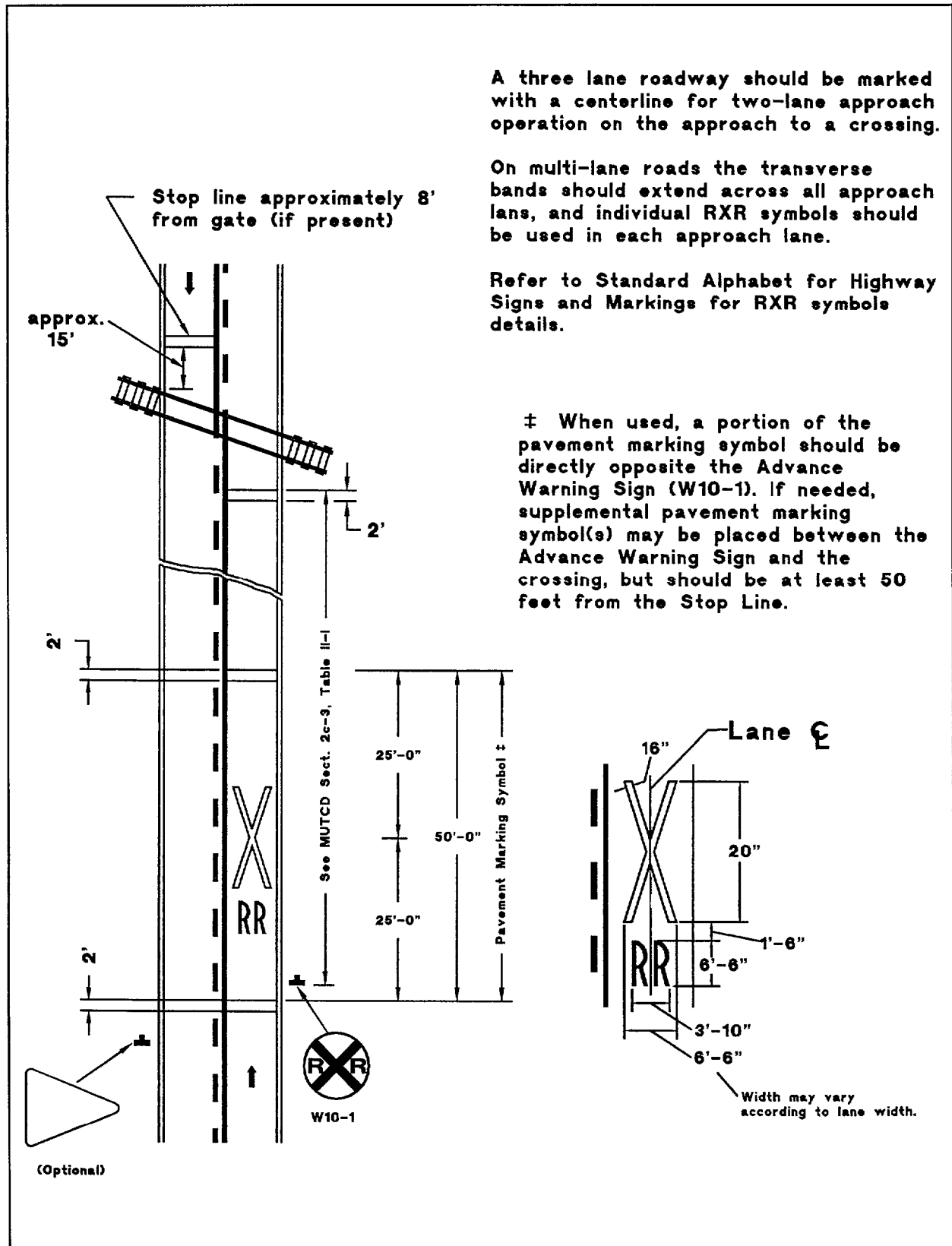
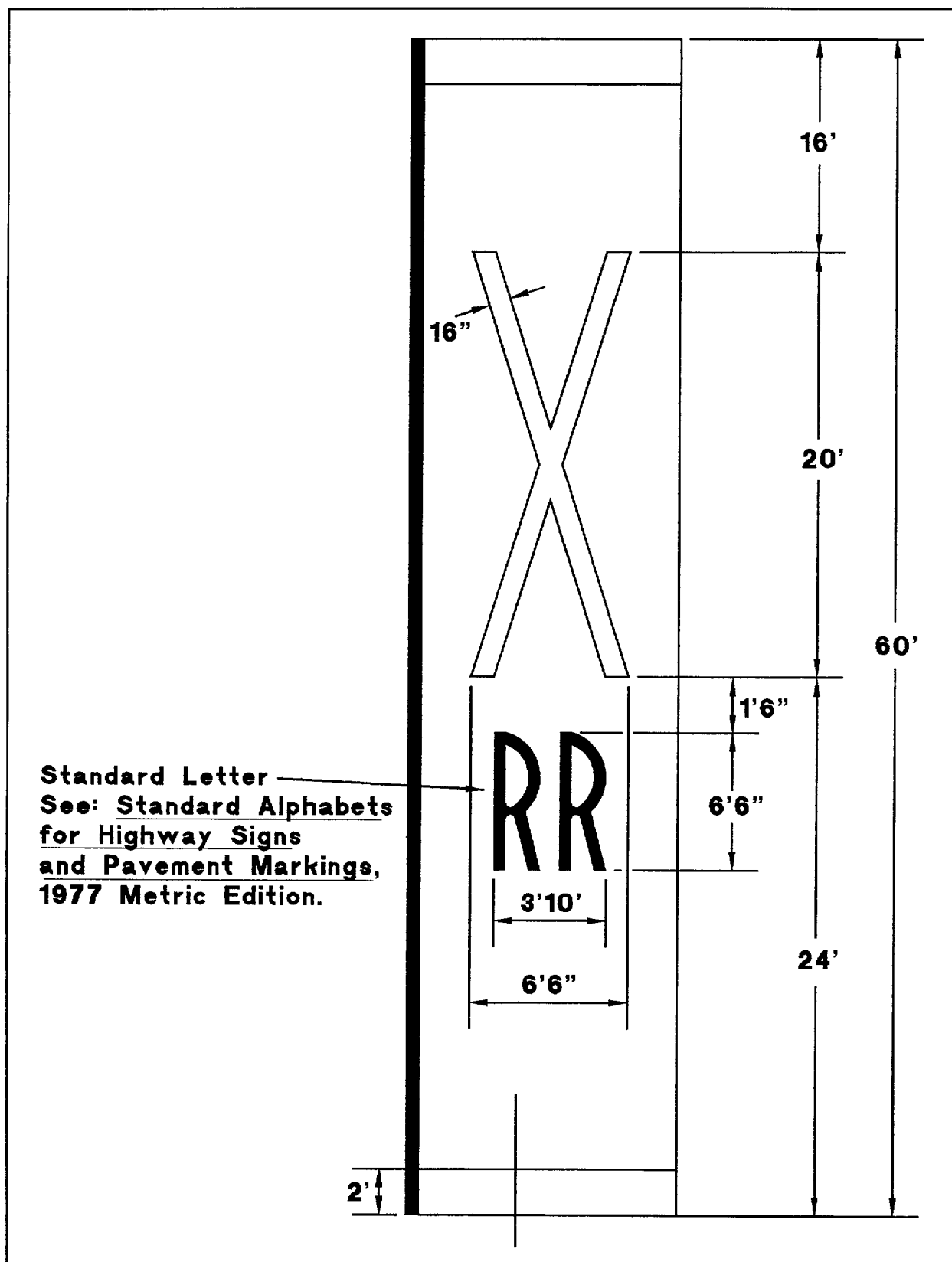


Figure 73. Typical placement of warning signs and pavement markings at railroad-highway grade crossings



**Figure 74.** Alternate (narrow) typical pavement marking supplement for railroad-highway grade crossings

### *General Principles*

Although bicycles are not equipped with strong lighting, the added visibility of retroreflective pavement markings is desirable even where there is exclusive use by bicyclists. Markings should be retroreflective on bicycle trails and on facilities used by both motor vehicles and bicycles. Recognized bicycle lane design guides should be used when laying out markings for a bicycle lane on a highway facility (*MUTCD* section 9A-8).

The frequent use of symbols and word messages stenciled in the bicycle lanes is a desirable method of supplementing sign messages. Figures 75 through 77 show acceptable examples of the application of markings, word messages, and symbols on designated bicycle lanes with and without parking for automobiles. If a specific path for a bicyclist crossing an intersection is to be designated, a dotted marking may be used to define such a path.

### *Marking Patterns and Colors*

The color and type of markings used for marking bicycle facilities are defined in *MUTCD* section 3A-7. Normally, centerlines would not be required on bicycle paths. Where conditions make it desirable to separate opposing directions of travel at particular locations, a double solid yellow marking should be used to indicate no passing or no traveling to the left of the marking.

Where bicycle paths are wide enough to designate two minimum width lanes, a broken yellow marking may be used to separate the two directions of travel.

Broken markings used on bicycle paths should have the normal 3-to-1 gap-to-segment ratio. To avoid excessively long gaps, a nominal 3-foot (1-meter) segment with a 9-foot (3-meter) gap is recommended.

Where bicycles and pedestrians use a common facility, it may be desirable to separate the two traffic flows. Use a solid white marking to mark this separation of path use. The *MUTCD* R9-7 sign may be used to supplement the pavement marking (*MUTCD* section 9B-9).

### *Marking of Designated Bicycle Lanes*

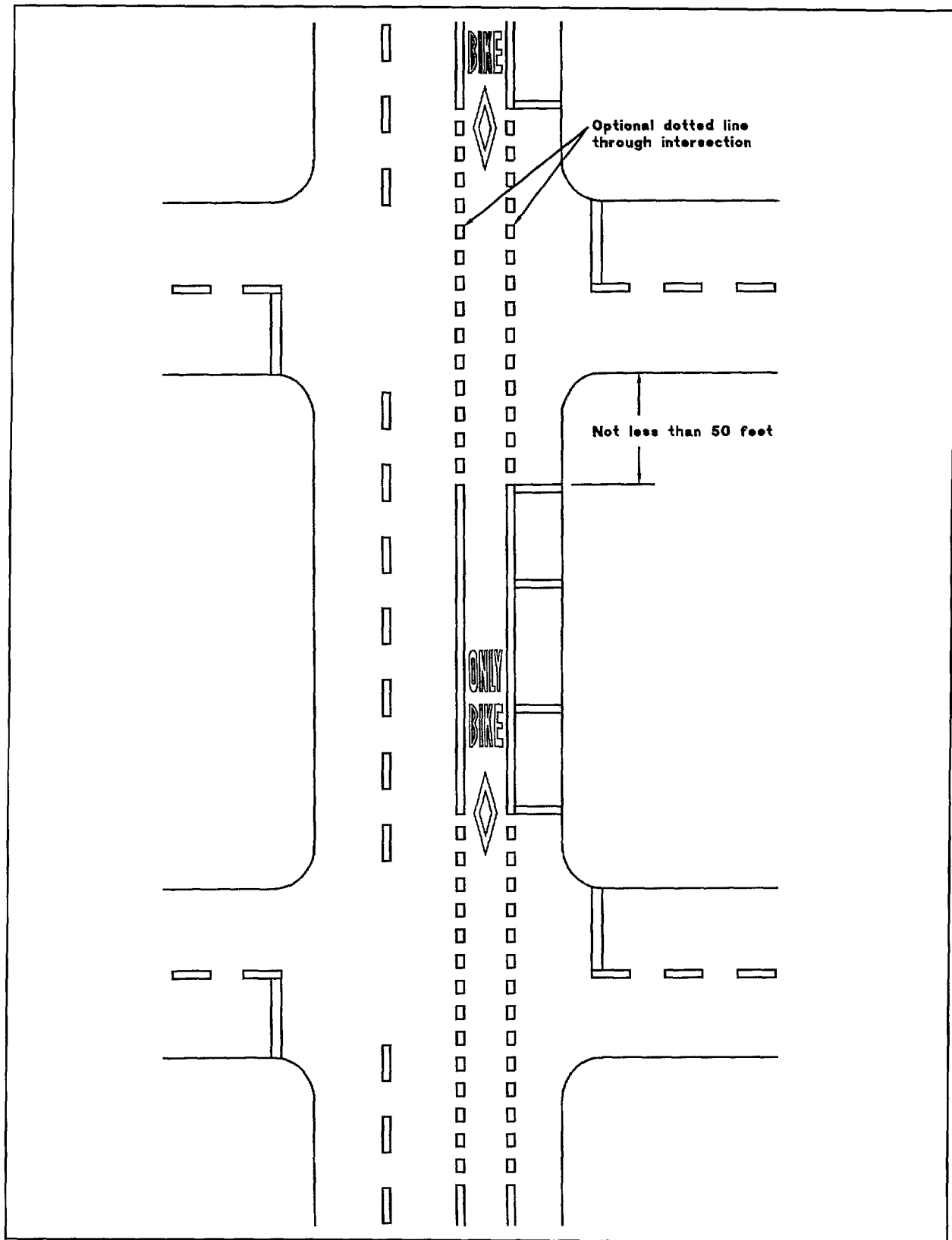
The diamond-shaped Preferential Lane Symbol is used on roadways where lanes are reserved for exclusive use by a particular class of vehicle. Designated bikeways are considered as this type of lane and should include use of the Preferential Lane Symbol as a pavement marking, with the appropriate signing (*MUTCD* section 9B-8). The pavement marking symbols should be white and should be used just after an intersection to inform drivers of the lane restriction. If the Preferential Lane Symbol is used in conjunction with other word or symbol messages, it should precede them. The supplemental lane symbol or word may be used as shown in figures 75 through 77.

### *Word Messages and Symbols*

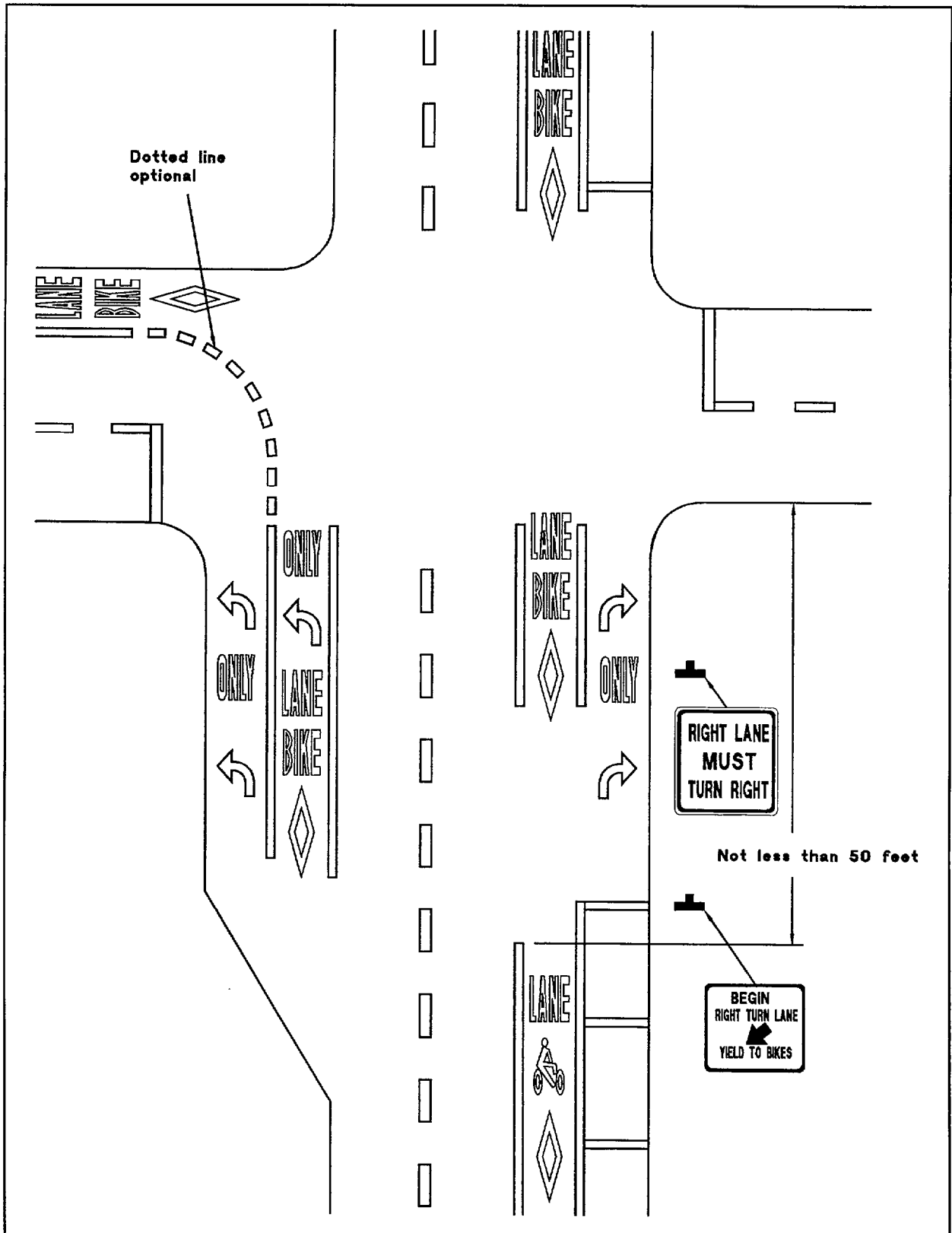
Where messages are to be applied on the pavement, smaller letters can be used on exclusive bicycle lanes than are used on regular highways. Use half-size layouts of the arrows where arrows can be used (*MUTCD* section 3B-17). Word and symbol markings appropriate for use with the Preferential Lane Symbol marking are shown in figure 77. Standard pavement marking alphabets and symbols have been prepared.

### *Object Markers on Bicycle Trails*

There may be hazardous objects located adjacent to bicycle trails that, if visible to the bicyclist, can be avoided with little difficulty. Such objects should be demarcated by highly visible markings to make the hazard they present more easily seen. Care should be taken to avoid having object markers become hazardous objects. Corners



**Figure 75.** Typical pavement markings-designated bicycle lane, two-way traffic with parking and low right-turn volume



**Figure 76.** Intersection pavement markings-designated bicycle lane with left-turn area, heavy turn volumes, parking, one-way traffic or divided roadway

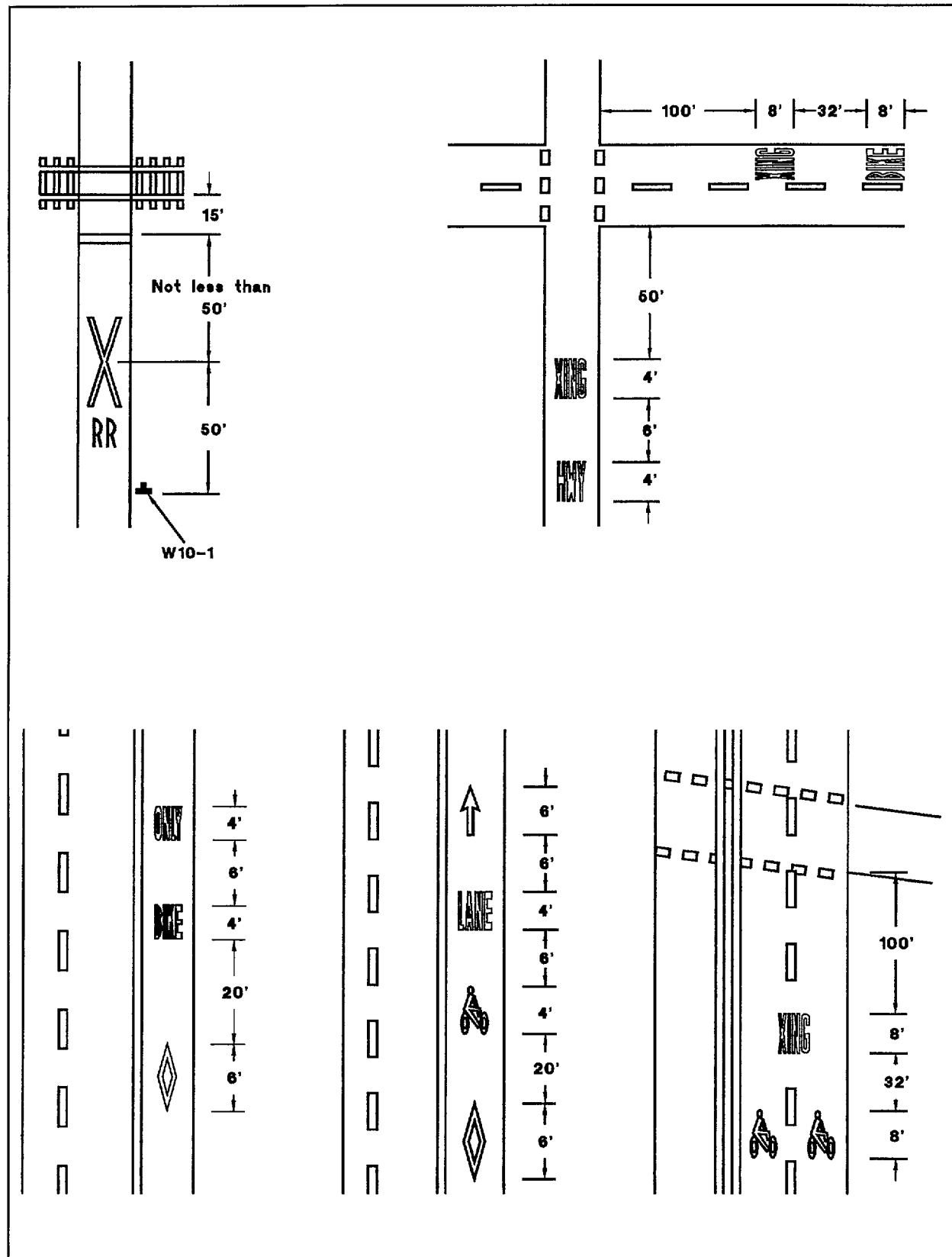


Figure 77. Word and symbol pavement markings for bicycle facilities

of object markers, as well as designs, should be rounded to prevent their becoming a hazard. All object markers should be designed using retroreflective materials or coatings. Where practical, markers, such as those described above, should be used.

#### *Inlets, Grates, and Other Hazards*

Where a storm drain hazard cannot be eliminated, it may be made more visible to bicyclists by defining with a white marking applied as shown in figure 78.

### PERFORMANCE

Pavement symbols and other delineation devices have the same visibility and durability as other pavement markings. That is, object markers and signs may lose their retroreflectivity and their night visibility will be reduced considerably. The previous chapters discuss performance for the specific delineation materials.

### INSTALLATION, MAINTENANCE, AND REMOVAL

Installation, maintenance, and removal techniques for other delineation devices vary greatly depending on the class of the device. The following sections discuss major factors for object markers, warning signs, barrier delineators, and pavement symbols.

### Object Markers

Inspect object markings on a regular basis for deterioration and vandalism. Also, the retroreflectivity of the markers can be checked using standard auto low beams for adequate visibility distances.

When used for marking objects in the roadway 8 feet (2.4 meters) or less from the shoulder or curb, the mounting height to the bottom of the object marker should be 4 feet (1.2 meters) above the surface of the nearest traffic lane. When used for marking objects more than 8 feet (2.4 meters) from the shoulder or curb, the mounting height to the bottom of the object marker may be 4 feet (1.2 meters) above the ground.

When object markers or markings are applied to a hazardous object that by its nature requires a lower or higher mounting, the vertical mounting height may vary according to need.

### Warning Signs

Warning signs should be erected in accordance with the requirements for sign position as shown in figure 79.

Determining whether a particular curve needs to be signed depends on the speed at

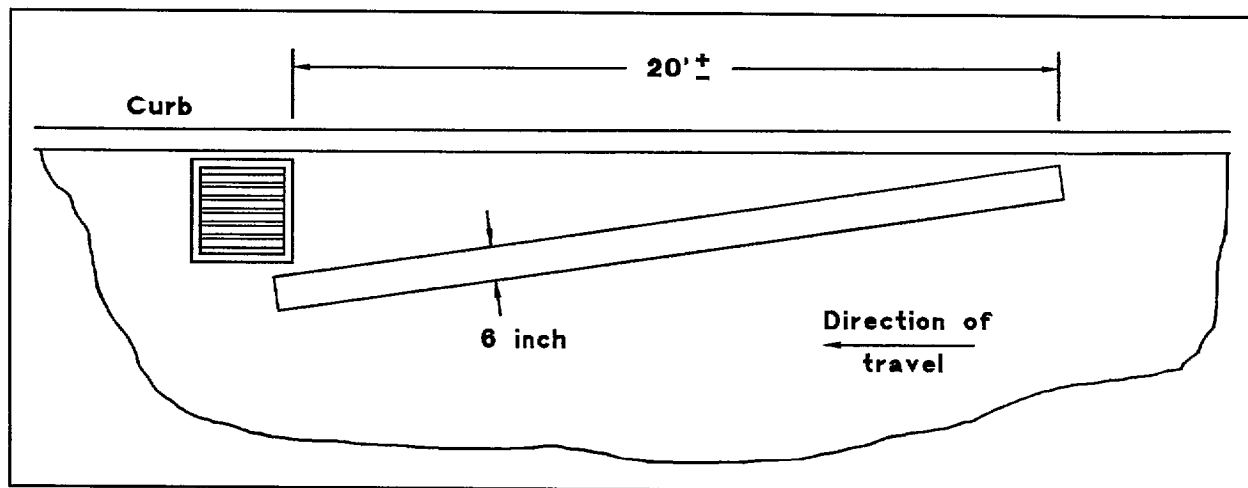


Figure 78. Typical marking in advance of drainage hazard

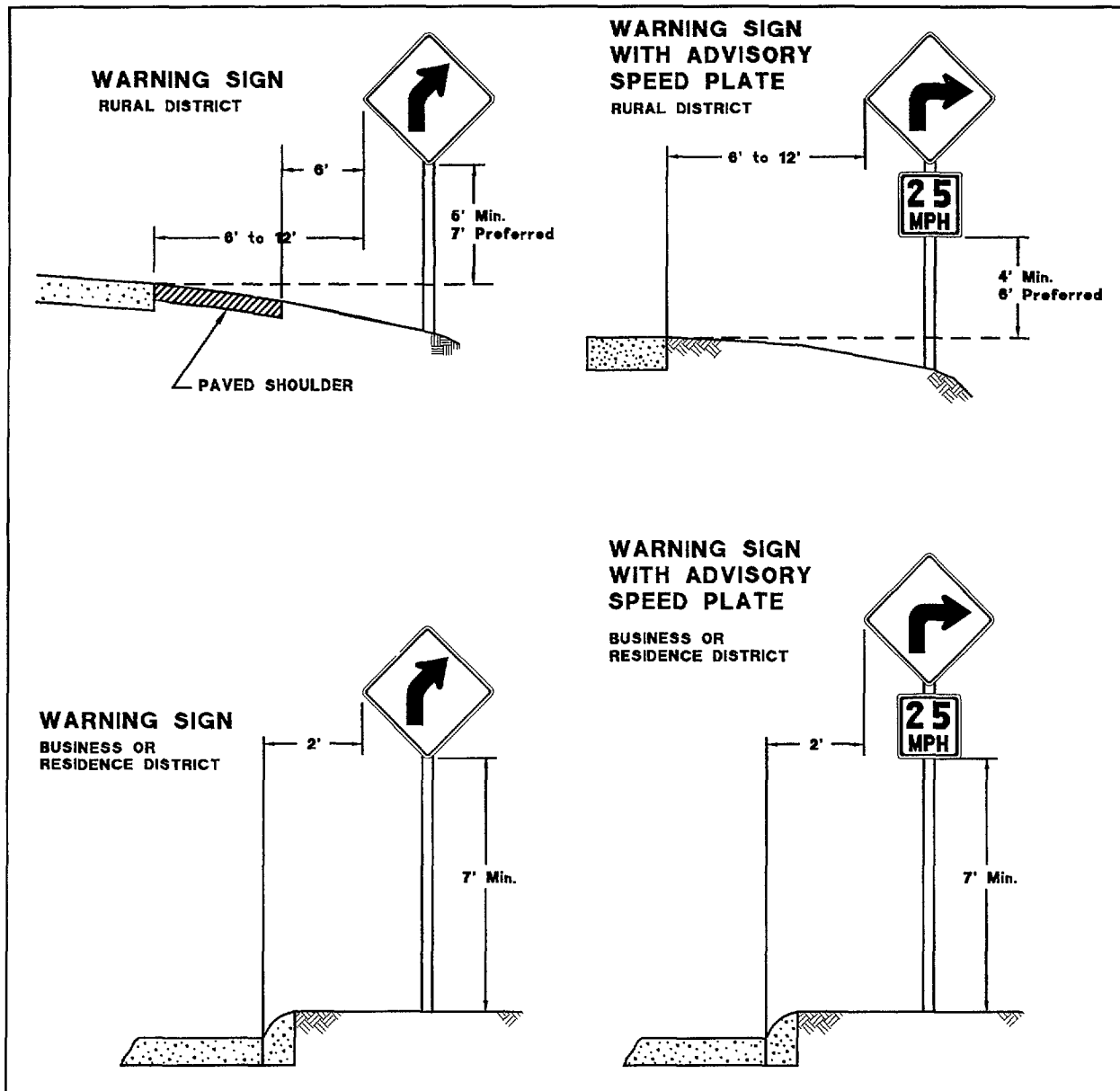


Figure 79. Typical installation of warning signs

which the curve may be safely traversed. This safe speed may be determined by any of three methods.<sup>(63)</sup>

The first method is a graphical technique. By knowing the curve radius and rate of superelevation, the recommended safe speed can be obtained from the graph in figure 80. Enter the vertical scale axis at radius,  $R$ . Move horizontally to the curve representing the superelevation,  $E$ .

Then move down the horizontal scale to get the safe speed.

The second method employs a mechanical device, the ball bank indicator. The ball bank indicator is mounted inside the 4-wheel vehicle and the safe speed around a curve is determined through a series of trial speed runs. The ball bank indicator's reading will show the combined effects of the body rolling angle, centrifugal force, and superelevation angle. Figure 81 shows

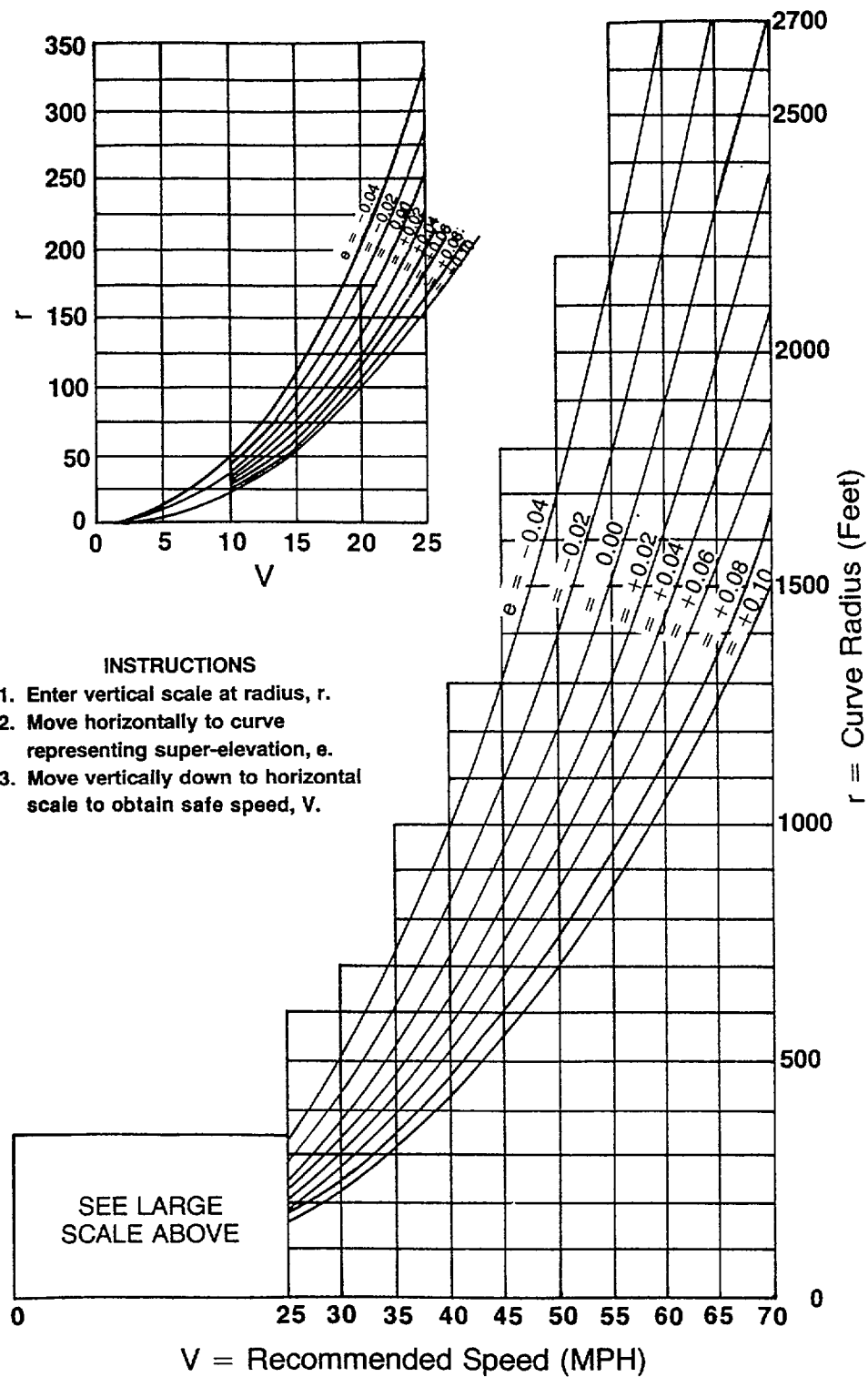


Figure 80. Recommended safe curve speed

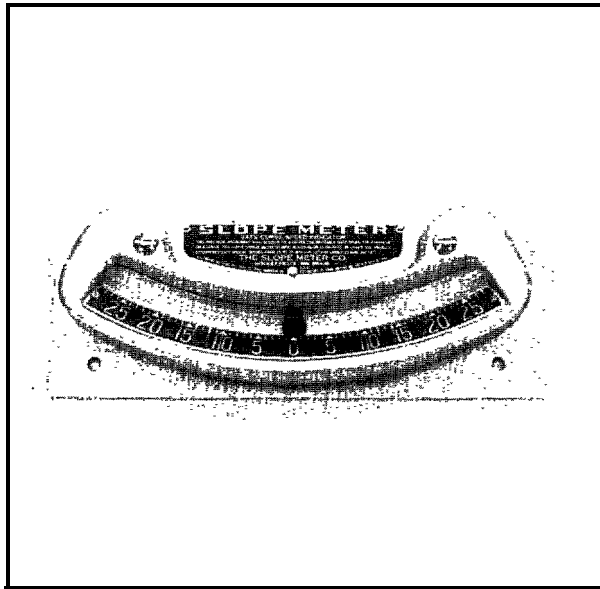


Figure 81. Ball bank indicator

pictures of a ball bank indicator. The vehicle is driven in a series of test runs, in both directions, parallel to the centerline of the curve. The curve should not be flattened out by driving the inside edge at the center of the curve.

The first trial run is made at a speed somewhat below the anticipated maximum safe speed. Subsequent trial runs are bank conducted with 5 mile per hour (8 kilometer per hour) speed increments. If a reading of 14 degrees or greater occurs at 20 miles per hour (32.2 kilometers per hour) or less, then the safe speed is below 20 miles per hour (32.2 kilometers per hour). The curve should be signed for 10 or 15 miles per hour (16 or 24 kilometers per hour), wherever a 14-degree reading occurs. For a safe trial speed of 20, 25, or 30 miles per hour (32.2, 40, or 48.3 kilometers per hour), a reading of 12 degrees is required. At trial speeds of 35 miles per hour (56.4 kilometers per hour) or greater, a reading of 10 degrees indicates the safe speed.

Evaluate curves in both directions when using this method. Many times it is preferable to use the lower speed condition for signing both approaches.

While many highway agencies use the 14-, 12-, and 10-degree system for signing curves, others use more conservative criteria. In some States for example, a 10-degree reading at any speed indicates the maximum safe speed. Prior to applying the ball bank indicator procedure, check the accepted criterion for the area in question.

The data acquisition system (shown in figure 82) is an electronic version of the ball bank indicator. It mounts in the test vehicle and is operated by the driver. The data acquisition system is used to establish highway posted curve speeds. The unit provides a printed reading of left and right curves; records distance, speed, and degrees of the test zone; records horizontal cross slope; records incline-testing information; and provides the data and time of tests. It is also personal-computer compatible.

A third method for determining the safe speed of a curve is to apply the following formula:

$$V^2 = 15 R (E + F)$$

Where:

V = speed in miles per hour (kilometers per hour)

R = radius of curve in feet (meters)

E = rate of superelevation in feet per foot (meters per meter)

F = safe coefficient of side friction

The recommended speed for the curve is determined by any one of the above methods, which in turn determines whether a turn or curve sign should be used.

Since warning signs are primarily for the benefit of the driver who is unacquainted with the road, it is important to place signs carefully. Warning signs should provide adequate time for the driver to perceive, identify, decide, and perform any necessary maneuver. This total time to perceive and complete a reaction to a sign is the sum of the times necessary for

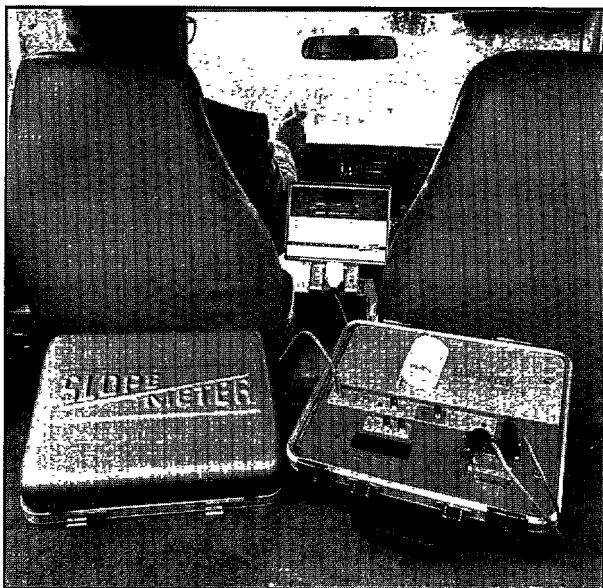


Figure 82. Electronic data acquisition system

perception, identification/understanding, emotion/decision-making, and volition/execution of decision, and is referred to as the PIEV time. The PIEV time can vary from about 3 seconds for general warning signs to 10 seconds for warning signs used in areas requiring high driver judgment.

Table 15 lists suggested minimum sign placement distances that may be used for three conditions:

*Condition A.* Driver will need extra time to make and execute a decision because of a complex driving situation (lane changing, passing, or merging).

*Condition B.* Driver will likely be required to stop.

*Condition C.* Driver will likely be required to decelerate to a specific speed.

Table 15 is an aid for determining warning sign location. The values in the table are for guidance only and should be applied with engineering judgment. The placement of temporary warning signs used at roadway construction and maintenance sites is covered in part 6 of the *MUTCD*. The minimum sign placement distances

given in table 15 may not apply to that group of signs.

The effectiveness of the placement of any warning sign should be tested periodically under both day and night conditions. Guidelines for inspecting and maintaining signs are presented in a FHWA report by McGee and Mace.<sup>(5)</sup> Inspection should include the following:

- Condition of sign face-major cracking, blistering, or missing message, visible from the roadway.
- Orientation and structural stability of the post.
- Discoloration, streaking, or fading of the sign.
- Visibility of the sign-roadside plantings or a new structure may be hiding the sign.
- Dirt or other substance on sign.
- Vandalism or accident that has damaged or removed the sign.
- Poor retroreflectivity.

All signs will experience diminishing retroreflectivity. The deterioration is a result of the sun's rays, moisture, pollutants, and even chemical reactions between the sheeting and the substrate. Loss of retroreflectivity also occurs from gun shots, spray paints, and vehicle impacts. Figure 83 shows vandalized signs.

Techniques to inspect for the loss of retroreflectivity from simple visual observations to the use of complex optical and electronic equipment. The most simple method is to drive at night and look for obviously deficient retroreflectivity. An experienced inspector can determine when a sign is ineffective.

Daytime inspection procedures also exist. A 200,000-candlepower spotlight is pointed at the sign as the vehicle moves along the road. The hand-held beam, powered by the vehicle's battery, is flickered across the sign face by the driver or passenger. With a little training, the

Table 15. Typical placement distances for general warning signs

Posted or 85th Percentile Speed		Listed Advisory Speed or Desired Speed at Hazard (mi/h)				
(mi/h)	(km/h)	10	20	30	40	50
Placement Distance of Sign in Front of Hazard (feet/meters) <sup>a</sup>						
20	32	(2)	---	---	---	---
25	40	100 <sup>(3)</sup> /30	5	---	---	---
30	48	150/46	100/30.5	---	---	---
35	56	200/61	175/53	---	---	---
40	64	275/84	250/76	175/53	---	---
45	72	350/107	300/91.5	250/16	---	---
50	81	425/130	400/122	325/99	225	---
55	89	500/152.5	475/145	400/122	300/91.5	---
60	97	575/175	550/168	500/152.5	400/122	300/91.5
65	105	650/198	625/191	575/175	500/152.5	375/114

Typical signs used in this manner include Turn and Curve. Placement distances shown are for level roadways. Corrections should be made for grades. If 48-inch signs are used, the legibility distance may be increased to 200 feet. This would allow reducing the above distance by 75 feet.

(1) Distance provides for 3-second PIEV, 125-foot sign legibility distance, braking distance as indicated in *A Policy on Geometric Design of Highways and Streets*, AASHTO, Figure 1 I-1 3, 1984.

(2) No suggested minimum distance provided. At these speeds, sign location depends on physical conditions at the site.

(3) In urban areas, a supplementary plate underneath the warning sign should be used specifying the distance to the hazard if there is an intersection which might confuse the driver between the sign and hazard.

inspector can detect failing signs. Figure 84 shows the spotlight, which plugs into the vehicle's cigarette lighter, and an application of its daytime use to check a sign's retroreflectivity.

Figure 85 shows an example of a warning sign with deteriorated retroreflectivity. The high-powered spotlight shining on the signs illustrates that the older, deteriorated sign on the left (ICE ON BRIDGE) exhibits little retroreflectivity. The newer sign on the right (CAUTION BRIDGE MAY ICE IN WINTER) is bright and appears to glow.

The most accurate method is to use a portable retroreflectometer to measure the sign's retroreflectivity in the field. The procedure is time-consuming and should be limited to questionable signs detected by a visual inspection or for those signs identified for possible replacement by a sign

inventory. In figure 86, the retroreflectivity of warning signs are being checked with the portable retroreflectometer.

The FHWA has developed a mobile unit for measuring sign retroreflectivity. The Traffic Sign Evaluator (TSE) is mounted in a van and records the sign retroreflectivity as the van travels along the roadway during daylight hours. The device is well-suited for highway agency sign management programs.

Sivak and Olson found that the geometric mean of replacement luminance value recommended in seven other research studies was 0.23 candelas per square foot (2.4 candelas per square meter).<sup>(88)</sup> This is the suggested replacement value. This would apply to light legends with dark (green, blue, red, and brown) backgrounds of up to 0.04 candelas per square foot (0.4 candelas per square meter) and to light (white, yellow and orange) backgrounds with

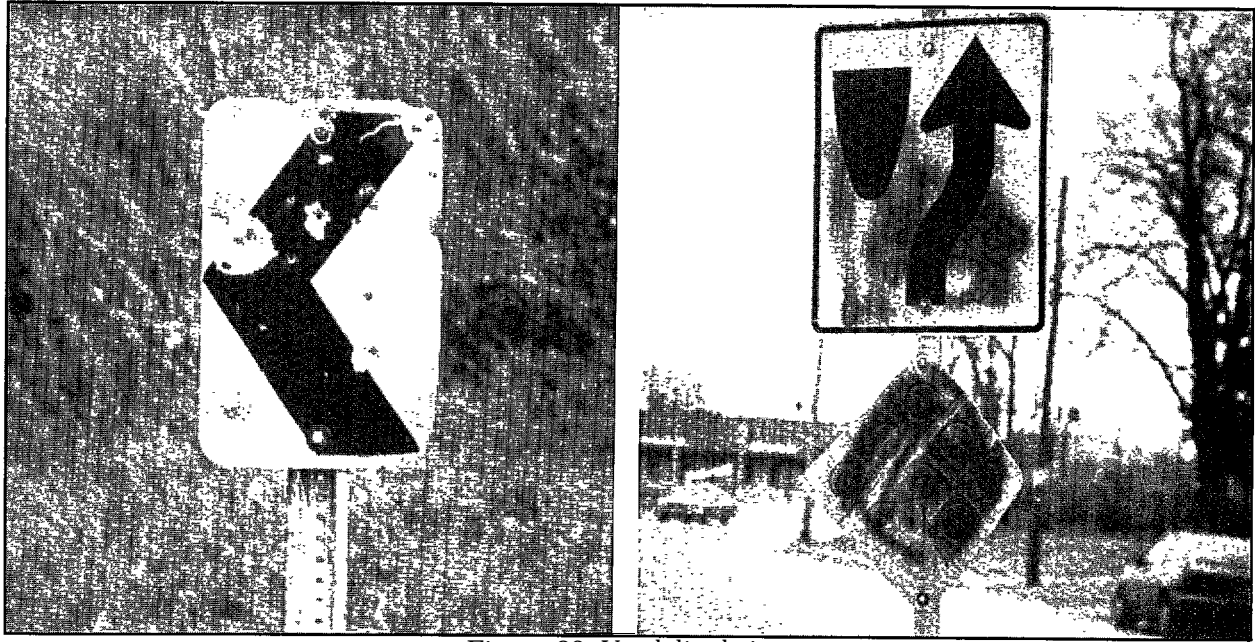


Figure 83. Vandalized signs

black legends. Also, it assumes a 50-feet-per-inch (6-meters-per-centimeter) letter height for studies that use younger subjects and 40 feet per inch (4.7 meters per centimeter) for older subjects. Assuming an optimal sign luminance of 7.0 candelas per square foot (75 candelas per square meter), they suggest the coefficients of retroreflec-

tion for four sign locations as shown in table 16.

Using the median value of 0.23 candelas per square foot (2.4 candelas per square meter) relates to a replacement percentile of only 50 percent. Factors that suggest an upward adjustment include headlight

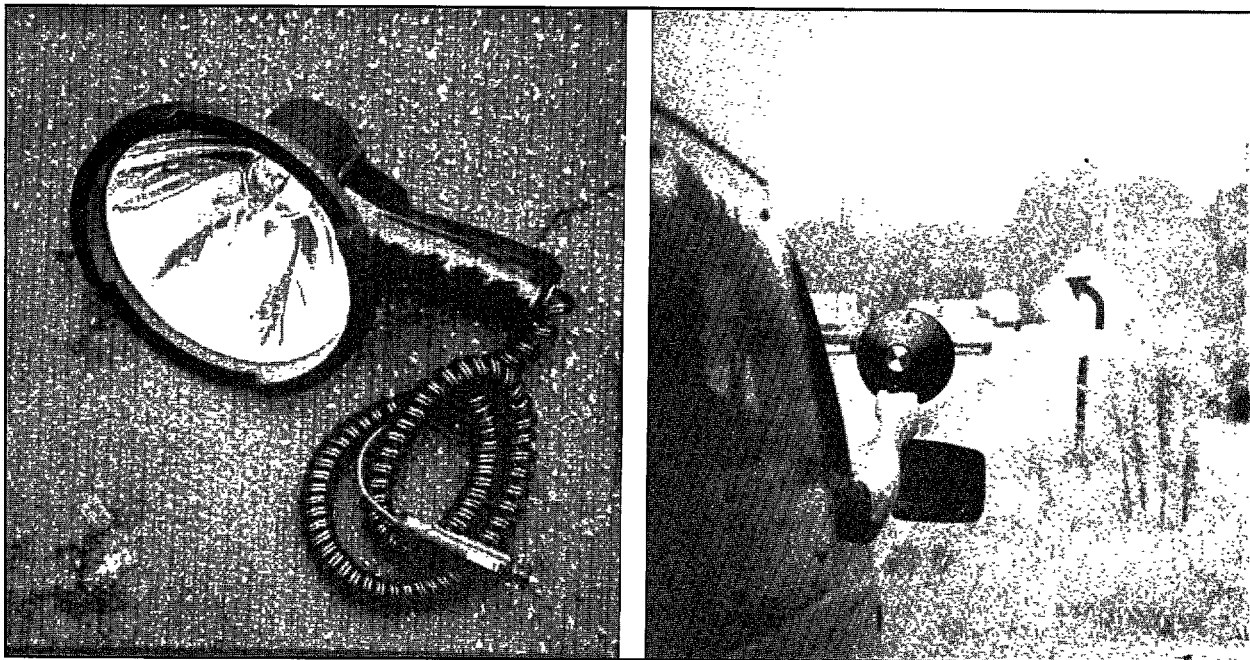


Figure 84. Daytime inspection of sign retroreflectivity

Table 16. Replacement coefficients of retroreflectance using US-type low beam headlights

<i>Sign Location</i>	<i>Replacement Coefficient of Retroreflection (candelas per lux per square meter)</i>
Left-hand side	90
Overhead-mounted	114
Right-hand side	24
Ground-mounted guide signs	27

systems using European-type low beam, high-luminance surroundings and environmental glare, driver age, truck drivers' observation angle, drivers under the influence of alcohol or otherwise impaired, dirty signs, and dirty or misaligned headlights.

Sign maintenance is important to keeping the retroreflectivity at acceptable levels. Signs should be checked for damage and cleanliness during regular inspections.<sup>(89)</sup> Damaged signs may be repaired using overlay techniques. Small signs may be recycled by stripping the sign face and applying new sheeting.

Most permanent warning signs do not need to be washed. However, in some locations a mild nondetergent solution can



Figure 85. Warning sign with deteriorated retroreflectivity

be used, if needed, to remove dirt. Other methods exist for cleaning special problems.<sup>(89)</sup>

### Barrier Delineators

Barrier delineators actually comprise a variety of different techniques of mounting or attaching retroreflective delineation to portable concrete barriers (PCBs). As such, the installation techniques used may vary widely from one brand of delineator to another. Also, the highway agency must decide whether the barrier delineators must be top or side mounted, and how far apart they will be spaced.

Barrier delineators are similar to raised pavement markers (RPMs) in that the primary problem with their use is how quickly they become dirty. When dirty, barrier delineators' performance can degrade to the point where they are no longer considered effective. Side-mounted delineators aggravate this problem since they are closer to the road surface and have a tendency to collect more dirt and road splash from passing vehicles.

Top-mounted barrier delineators relieve the problem with collection of road splash somewhat, but their effectiveness is decreased with the side-mounted delineators in the presence of headlight glare from opposing vehicles.<sup>(89)</sup> Obviously, some compromise must be made between these two conflicting factors.



**Figure 86.** Use of a portable retroreflectometer

Even when delineators are top mounted, cleanliness remains a problem. A research study at the Texas Transportation Institute (TTI) by Ullman, Dudek, and Allen concluded that delineators are effective in improving driver performance, but that they must be cleaned to be most effective.<sup>(90)</sup> They conducted a survey of all the Texas DOT districts in an attempt to identify how this process was being accomplished. At the time of the report (1988), no viable methods were being used in place of hand cleaning was found.

Hand cleaning of barrier delineators is labor-intensive and usually involves a dangerously high level of exposure for the workers involved. The TTI study also reviewed alternate, safer methods of delineator cleaning. Three of the most promising are presented in the report, including a self-propelled rotating brush system, a truck-mounted brush head system, and a high-pressure water sprayer. The researchers found that the performance data were inconclusive at the time and that further research was needed in the area of fabrication and testing of these systems.

Barrier delineators are similar to PMDs in that they are not normally removed during their lifetimes. Barrier delineators are also not directly subjected to traffic wear, so knockdowns are not a concern as with PMDs. Maintenance and cleaning of the retroreflective faces is usually the prime concern.

### **Pavement Symbols**

Since pavement symbols are a form of pavement markings, their installation, maintenance, and removal follow the guidelines for the particular type of material. See the appropriate chapter for specific details.